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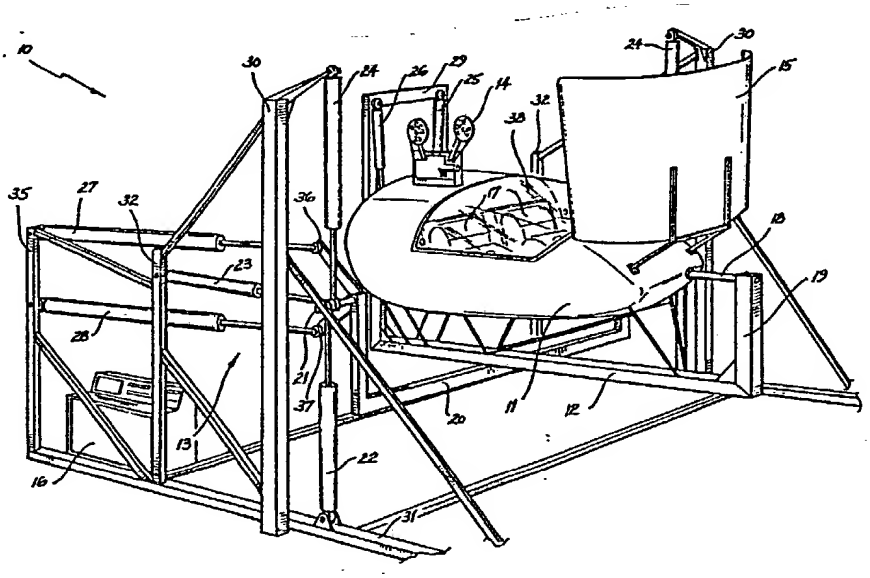


(57) Abstract

A glider flight simulator (10) which comprises a simulated cockpit (11) which includes a seat (17) for a user; a gimbal suspension (12) for the cockpit (11) so mounted on a frame (31) that the cockpit (11) may be moved with at least two rotational degrees of freedom and at least one translational degree of freedom; a plurality of hydraulic or pneumatic rams (21, 23, 24, 27, 28) connected between the frame (31) and the suspension (12) to move the cockpit (11); a projector (14) and screen (15) arrranged to provide a visual image in the field of view of a person in the cockpit (11); and control means (16) to control the hydraulic or penumatic rams (21, 23, 24, 27, 28) such that the cockpit (11) may be moved in a manner corresponding to images displayed on the screen (15).

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# GLIDER FLIGHT SIMULATOR

The present invention relates to a flight simulator and more particularly a flight simulator which provides the sensation of flight experienced in a fixed wing glider.

Flight simulators are well known and are widely used to train pilots of powered aircraft. Such flight simulators being described, for instance in U.S. patent specifications 1,865,828; 2,396,660; and 3,101,645. In all of these flight simulators the emphasis is on training pilots in the mechanical operations of powered flight. In powered flight a pilot can by appropriate manipulation of the controls cause his aircraft to move in any desired direction at will. In unpowered gliders, by contrast, the movement of the aircraft can be determined by manipulation of the controls but only within the ambit of the potential offered by the environment in which the glider is flying. If the glider is in an updraft then the glider can be made to climb but if it is in a downdraft there is no way in which the pilot can overcome its effects other than by flying out of it and finding a suitable updraft. In flying gliders it is therefore far more important for the pilot to gain experience in the "feel" of the interaction between the craft and its environment. The present invention provides a flight simulator which can be used to train glider pilots such that they can learn how the craft feels in flight and/or which may be used to give members of the general public the sensation of glider flight without their having to assume the risks of actual glider flying.

It is also known from the present inventor's U.S. patent application 210,025 that hang-glider flight simulation may be obtained by the use of a device comprising a pilot suspending means, a control means, means from which the pilot suspending means and control means are suspended, means associated with said means from which said pilot suspending means and control means are suspended for manoeuvering the pilot suspending means and said control means to simulate movements occurring

during hang gliding, visual display means positioned to be viewed by a pilot in the pilot suspending means and means for synchronising said means for manoeuvering with said visual display means so that in use movements simulated by said means for manoeuvering correspond to images displayed by the visual display means.

In hang-gliding the pilot is suspended by a flexible strap from the glider and therefore it is only necessary to provide for the pilot to rise and fall relative to the suspending means. The movement of a hang glider is controlled by control means which normally comprises an A-shaped control bar. If the hang-glider is to rise or fall the control bar is moved respectively forwards or backwards. While this earlier invention has proved successful in simulating hang-glider flight it cannot reproduce the bodily sensations experienced by a pilot in a fixed wing glider where the pilots body is strapped into a cockpit and the pilot's whole body therefore moves with the cockpit in all of its movements.

The present invention consists in a glider flight simulator, comprising:-

(a) a simulated cockpit containing seating means,

(b) suspension means suspending the cockpit from a frame such that the cockpit may be moved with at least two rotational degrees of freedom and at least one translational degree of freedom,

(c) movement means connected between the frame and the suspension means to move the cockpit,

(d) visual display means to display an image visible from the seating means, and

(e) control means to control the movement means such that the cockpit may be moved in a manner corresponding to images displayed on the visual display means.

The simulated cockpit preferably comprises a shell of monocoque construction that contains seats for one or two

users. In the interests of realism the seats are preferably of the moulded plastics material type commonly found in fixed wing gliders. The seats are also preferably provided with conventional pilot harnesses to strap the users into the seats.

The suspension means preferably comprises a structure so connected to the cockpit that the cockpit can be moved through at least two degrees of rotational freedom and through at least one and preferably two translational degrees of freedom. In each case it will be recognised that a limited range of movement within any degree of freedom will be sufficient to impart the appropriate sensations to the user. In the case of each one of the degrees of rotational freedom movement backwards and forwards through an angle of as small as $5^{o}$ or $10^{o}$ may be all that is necessary to give the sensation of the turning, rolling or pitching movement of a fixed wing glider. Although small angular movements may be used to provide users with the sensation of movement it is preferred that the suspension means are such that the cockpit may be moved through a total included angle of at least $60^{o}$, and more preferably through a total included angle of $120^{o}$, on each of its axes of rotational movement. Similarly linear movement backwards and forwards over a relatively short distance may be all that is necessary to provide sensations of lift, side slip, and acceleration or deceleration.

The suspension means preferably comprises a gimbal arrangement which permits pivoting of the cockpit about two mutually perpendicular horizontal axes through the centre of gravity of the cockpit. The gimbal arrangement is preferably mounted for movement as a whole in two orthogonal planes and, preferably, for rotation about a vertical axis mutually orthogonal to the two horizontal axes of the gimbal arrangement.

The movement means may comprise any suitable mechanism

which can bring about controlled movement of the various integers of the suspension means to provide suitable motion to the cockpit. Stepping motors connected to suitable transmission means could for instance be used as could suitably controlled solenoids. It is particularly preferred however to control all of the movements through hydraulic or pneumatic rams, most preferably double acting rams. It has been found that such rams, when suitably dimensioned can impart a softness of movement which faithfully reproduces the movement of a fixed wing glider in flight. An ability to move the cockpit rapidly may also be important in some circumstances and the use of hydraulic or pneumatic rams facilitates this.

The visual display means preferably comprises a screen visable from the seating means and a film projector to project a film image onto the screen. In one embodiment of the invention the projector and the screen are both mounted on the cockpit and move with it. In other embodiments of the invention they may both be mounted independently of the cockpit. In a further alternative arrangement the projector or the screen may be mounted on the cockpit while the other of the pair is mounted independently of the cockpit.

The screen is preferably a parabolic screen which surrounds a windscreen on the cockpit to an extent that the screen occupies substantially the whole field of vision of a user of the flight simulator. The projector preferably has a wide angle lens such that the projected image substantially completely fills the screen.

The visual display means may comprise a video screen rather than a screen to receive a projected cinematographic image.

The control means may be of two distinct types dependant upon the use to which the simulator is to be put. In the case where the simulator is to be used purely to provide "joy-rides" to members of the general public and is not be

used as a flight control teaching aid the control means comprises a mechanism which actuates the suspension means such that the cockpit is caused to move in a manner dictated by encoded instructions which reproduce the movements of the glider from which the film being shown on the screen was taken. In this embodiment of the invention conventional glider "controls" such as rudder foot controls and hand elevator and aileron control means may be provided as well as conventional instrumentation, however, all of these "controls" and instruments will be caused to move in response to movement of the suspension means rather than to initiate such movement. The projector and screen are preferably both mounted on the cockpit in this embodiment of the invention.

The mechanism which actuates the suspension means preferably comprises a microprocessor programmed to control the suspension means in synchronisation with a particular film or any one of a number of selected films. The microprocessor preferably serving to control the flow of a hydraulic or pneumatic fluid to the hydraulic or pneumatic rams constituting the suspension means by the opening and closing of appropriately arranged valves.

In another embodiment of the invention the control means are such that student pilots can actively cause the cockpit to move under the influence of the movement means in a manner which reproduces, as far as the pilot can, the movement of the glider from which the film was taken. In this embodiment the projector, or the screen, is preferably mounted on the cockpit while the other is mounted independently. If the film image and the screen each carry indicia which can be brought into register when the cockpit is moving in correspondence with the glider from which the film was taken the pilot can manoeuver the cockpit using the control means to try and ensure that the indicia on the screen and on the film image are substantially constantly in register.

The glider flight simulator is designed to be used in a

room or other housing which may be darkened to enable the film image on the screen to be clearly seen. If desired sound effects may be broadast in the room to reproduce the aural sensations of glider flight.

Hereinafter given by way of example only is a preferred embodiment of the invention described with reference to the accompanying drawings in which:-

Fig. 1 is a perspective view of a glider flight simulator according to this invention;

Fig. 2 is a side elevational view of the glider flight simulator of Fig. 1;

Fig. 3 is a rear elevational view of the glider flight simulator of Fig. 1;

Fig. 4 is a plan view of the glider flight simulator of Fig. 1;

Fig. 5 is a schematic diagram showing the manner in which the control means controls the movement means;

Fig. 6 is a schematic diagram showing the manner in which the air supply to pneumatic rams constituting the movement means is controlled, and

Fig. 7 is a schematic diagram showing electronic control of solenoid drivers forming part of the control means.

The glider flight simulator 10 comprises in essence a cockpit 11, a gimbal suspension 12, an array of pneumatic rams constituting movement means 13 supporting and moving the gimbal suspension 12, a film projector 14 for projecting a film image onto a screen 15 and control means 16 for controlling the pneumatic rams 13 such that the cockpit 11 in the gimbal suspension 12 may be moved by the pneumatic rams 13 in a manner corresponding to the film image displayed on the screen 15.

The cockpit 11 is of monocoque construction and is shaped to conform with a conventional glider cockpit. The cockpit 11 includes a pair of seats 17 for users to sit in and conventional pilot harnesses (not shown).

The cockpit 11 is provided with a transparent windscreen 38 through which a pilot may view the screen 15. The screen 15 is parabolic and wraps around the cockpit to cover substantially the whole field of vision of a pilot in the cockpit.

The cockpit 11 is formed with a spindle 18 extending through the cockpit 11 along its longitudinal axis. The spindle 18 is journalled at either end in a U-shaped yoke 19 forming part of the gimbal suspension 12. The yoke 19 is attached to an orthogonally extending U-shaped yoke 20. The upper ends of yoke 20 carry outwardly extending pins 21.

The gimbal suspension 12 is supported on each side by three pneumatic rams 22, 23 and 24 which form part of the movement means 13. The rams 22, 23 and 24 are each connected at one end to one of the pins 21, rams 22 and 24 serve to move the associated pin 21 in a vertical plane while the ram 23 serves to move it in a horizontal plane.

The rams 22 are pivotably connected to a base frame 31 at the lower ends and have piston rods extending from their upper ends which are respectively journalled to one of the pins 21. The rams 24 are pivotably connected at their uppper ends to a support stand 30, piston rods extend from their lower ends and are respectively journalled to one of the pins 21. The rams 23 extend horizontally from frame members 32 to which they are pivotably connected, piston rods extend from the ends of the rams 23 and are journalled respectively to one of the pins 21.

The movement of the cockpit 11 in the yokes 19 and 20 is effected respectively by the pneumatic rams 25 and 26 and by the pneumatic rams 27 and 28 respectively. The rams 25 and 26 are connected at their upper ends to a side frame 29 connected to one end of yoke 19. Each of the rams 25 and 26 is connected to one of the upper corners of the frame 29 and the piston rods of these rams are journalled to rods 33 and 34 respectively which extend radially from spindle 18 to

which they are welded. Actuation of the rams 25 and 26 cause the cockpit 11 to be rotated about the axis of spindle 18.

The rams 27 and 28 are each connected at one end to frame members 35. A piston rod of the ram 27 is pivotably connected to the rod 36 which is welded to one end of the yoke 20. A piston rod of the ram 28 is pivotably connected to the rod 37 which is welded to the said one end of the yoke 20. Actuation of the rams 27 and 28 causes the cockpit 11 and the gimbal suspension 12 to be pivoted about the axis of the pins 21.

The rams are operated by a supply of dry air fed from a compressor (not shown) to a storage tank (not shown) through filters and a regulator valve.

The flow of compressed air to each side of each of the rams is regulated by the control means 16 which includes four solenoid valves 41 (see Fig. 6) each of which is followed by a flow control valve 42. Each solenoid valve 41 switches the air supply to its associated flow control valve 42 on and off. Each flow control valve 42 can be adjusted to give it a particular output which may vary from zero to the maximum of the supply. The four flow control valves 42 controlling each side of each ram are adjusted to give values of 1/2, 1/4, 1/8 and 1/16 of the maximum flow rate respectively. Taken together the solenoid valves 41 and the flow control valves 42 allow sixteen different flow rates to be specified for the air supply to each side of each ram.

For each solenoid valve 41 there is a microprocessor output from the control means 16 which is fed into an apto coupling device 43 (see Fig. 7). The apto coupling device 43 switches the 240 volt triac 44 on and off as required. As the triac 44 switches on and off, it applies a 240 volt current to the solenoid valve 41 which in turn switches the air supply on and off. The purpose of this arrangement is to isolate the microprocessor from the 240 volt circuit 45.

The movement of the each of the rams is sensed by a

sensor 46 through which passes a toothed rod 47 (for clarity the sensor 46 and rod 47 are shown only in place on ram 27, however, it is to be understood that each ram is so equipped). The sensor 46 produces a voltage output proportional to the position of the piston rod of the ram (see Fig. 5). This input is fed to the microprocessor 39 and is compared with the value given by the microprocessor program for the position in which the piston rod should be at that time in the program. The microprocessor 39 then produces an output which causes the piston rod to move until the value of the sensor equals the value determined from the program.

The control means 16 controls the actuation of the pneumatic rams and the actuation of the projector 14. The heart of the control means 16 is a microprocessor 39 (see Fig. 5). The microprocessor 39 controls the whole operation of the flight simulator which is actuated by a 'start button'. This controls lights and starts the film running in projector 14. The film then runs until it comes to the 'start pulse' on the film which starts the program running through the microprocessor 39. The sound is then started and the filmed flight program is now to be seen running. The first reaction is that the sensors 46 are presenting an output of an analog value of 0 to 10 volts to an analog digital converter 47. This gives a positional voltage respective to where the actuator is. This value is then converted to a digital 8-bit word data bus 48. The sensor word is compared to the word stored in read only memory, hereafter referred to as 'the program' in the microprocesssing unit 39.

If there is any difference between the sensor word and the program word, the difference is calculated for the correct output to the triac drivers 44 and hence to the flow system. The piston rod of the ram is moved until the sensor word equals the program word, and so on as each program word

tells it to move to the programmed position. This goes on moving the ram piston rod as required until the end of the program. The end of the program will be given by a 'pulse' on the film which signals the microprocessor operation to return the cockpit to the loading position, resets the sound tapes and the film, ready to start again, and also turns on the lights. It is then ready to be loaded and only needs the 'start button' pressed to run the program again.

The claims defining the invention are as follows:-

1. The present invention consists in a glider flight simulator, comprising:-

(a) a simulated cockpit containing seating means,

(b) suspension means suspending the cockpit from a frame such that the cockpit may be moved with at least two rotational degrees of freedom and at least one translational degree of freedom,

(c) movement means connected between the frame and the suspension means to move the cockpit,

(d) visual display means to display an image visible from the seating means, and

(e) control means to control the movement means such that the cockpit may be moved in a manner corresponding to images displayed on the visual display means.

2. A glider flight simulator as claimed in claim 1 in which the suspension means is such that the cockpit may be moved with at least two degrees of rotational freedom and two degrees of translational freedom.

3. A glider flight simulator as claimed in claim 1 or claim 2 in which the suspension means comprises a gimbal means connected to the cockpit such that the cockpit may be moved pivotably about two mutually perpendicular substantially horizontal axes, the gimbal means being mounted for movement in two orthogonal planes.

4. A glider flight simulator as claimed in any one of claims 1 to 3 in which the movement means comprises an array of hydraulic or pneumatic rams.

5. A glider flight simulator as claimed in any one of claims 1 to 4 in which the visual display means comprises a film projector and a screen mounted on the cockpit, the screen being substantially parabolic and extending around the cockpit so as to occupy substantially all of the field of vision of a user in the seat means.

6. A glider flight simulator as claimed in claim 5 in which

the control means comprises a mechanism which activates the suspension means such that the cockpit is caused to move in a manner dictated by encoded instructions which correspond to the movements of a glider from which the film being shown on the screen was taken.

7. A glider flight simulator as claimed in claim 6 in which the mechanism which activates the suspension means comprises a microprocessor programmed to control the suspension means in synchronisation with the film being projected onto the screen when the glider flight simulator is in operation.

8. A glider flight simulator as claimed in any one of claims 1 to 5 in which the control means comprise manually operable means in the cockpit which activate the suspension means.

9. A glider flight simulator as claimed in any one of claims 1 to 8 in which the cockpit is of monocoque construction and contains up to two seats.

10. A glider flight simulator substantially as hereinbefore described with reference to the accompanying drawings.

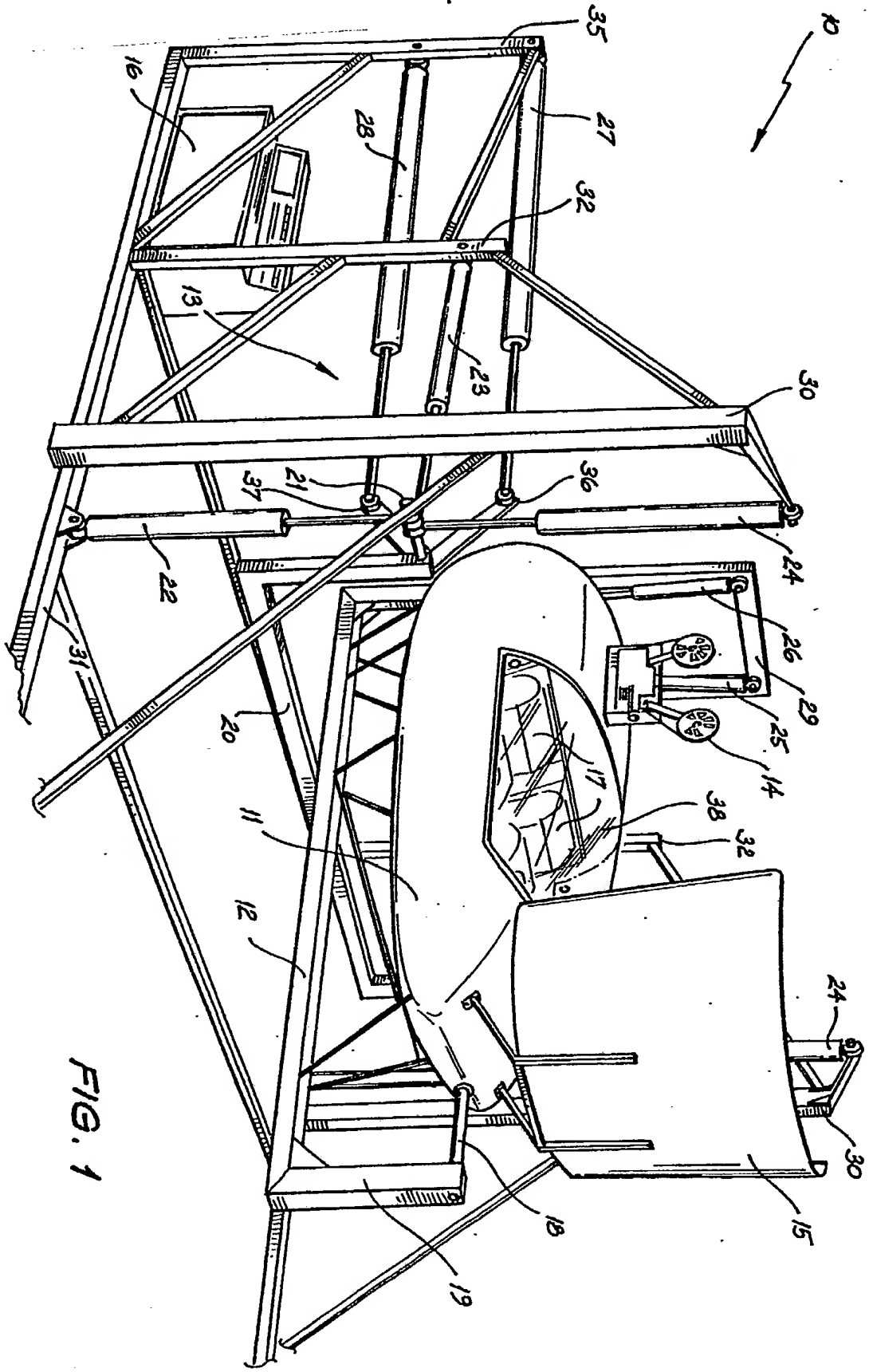


FIG. 1

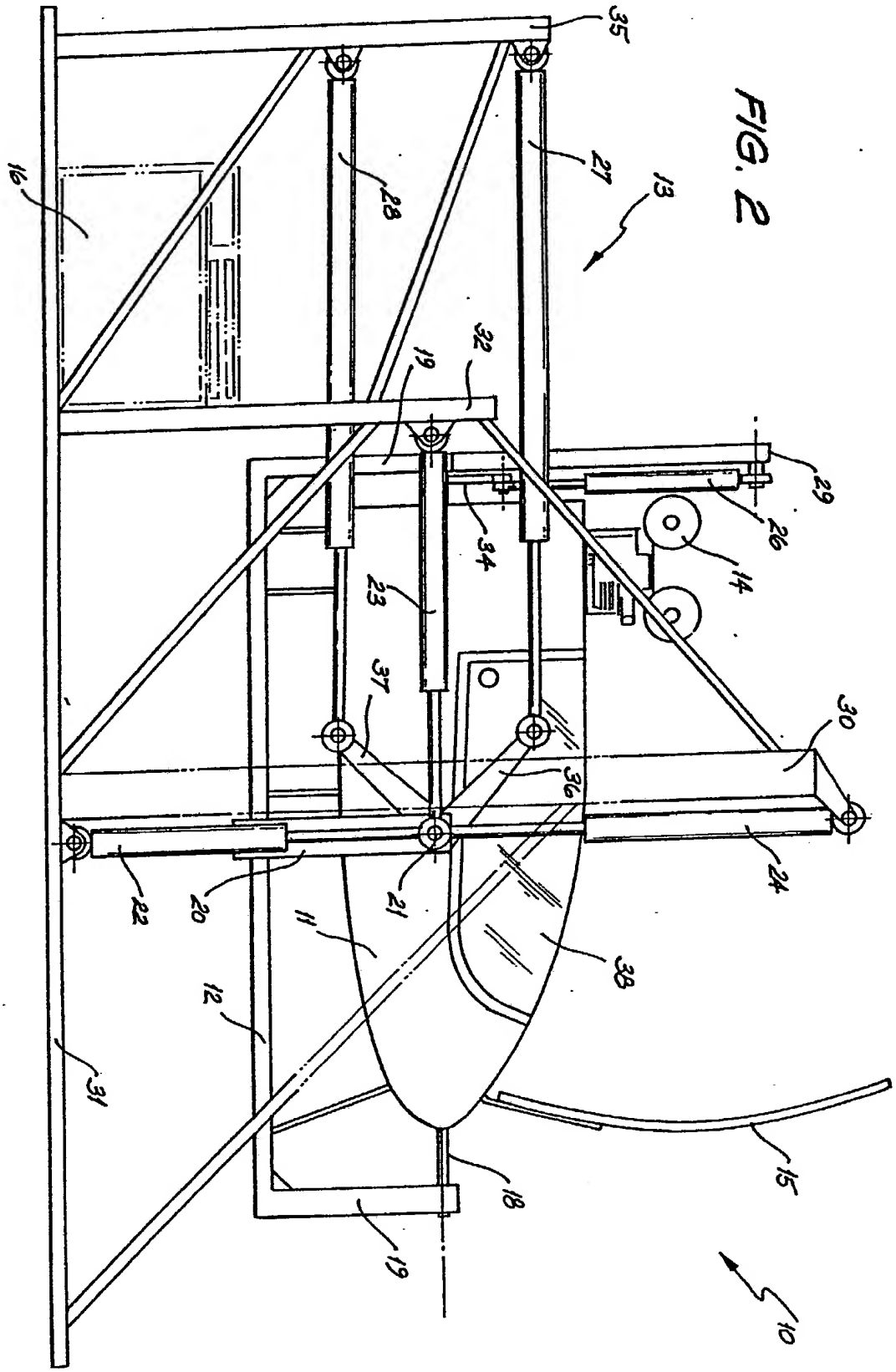


FIG. 2

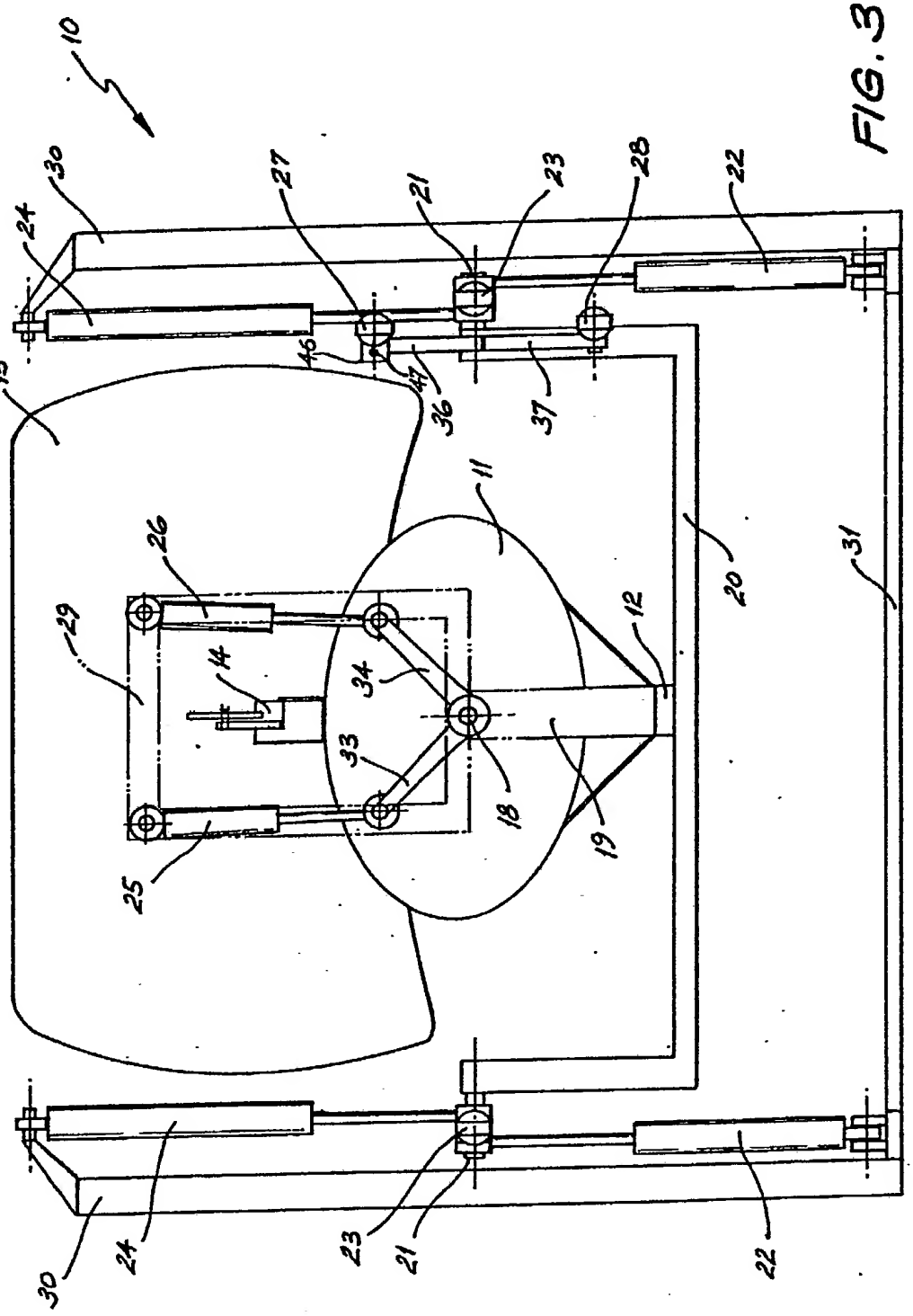


FIG. 3

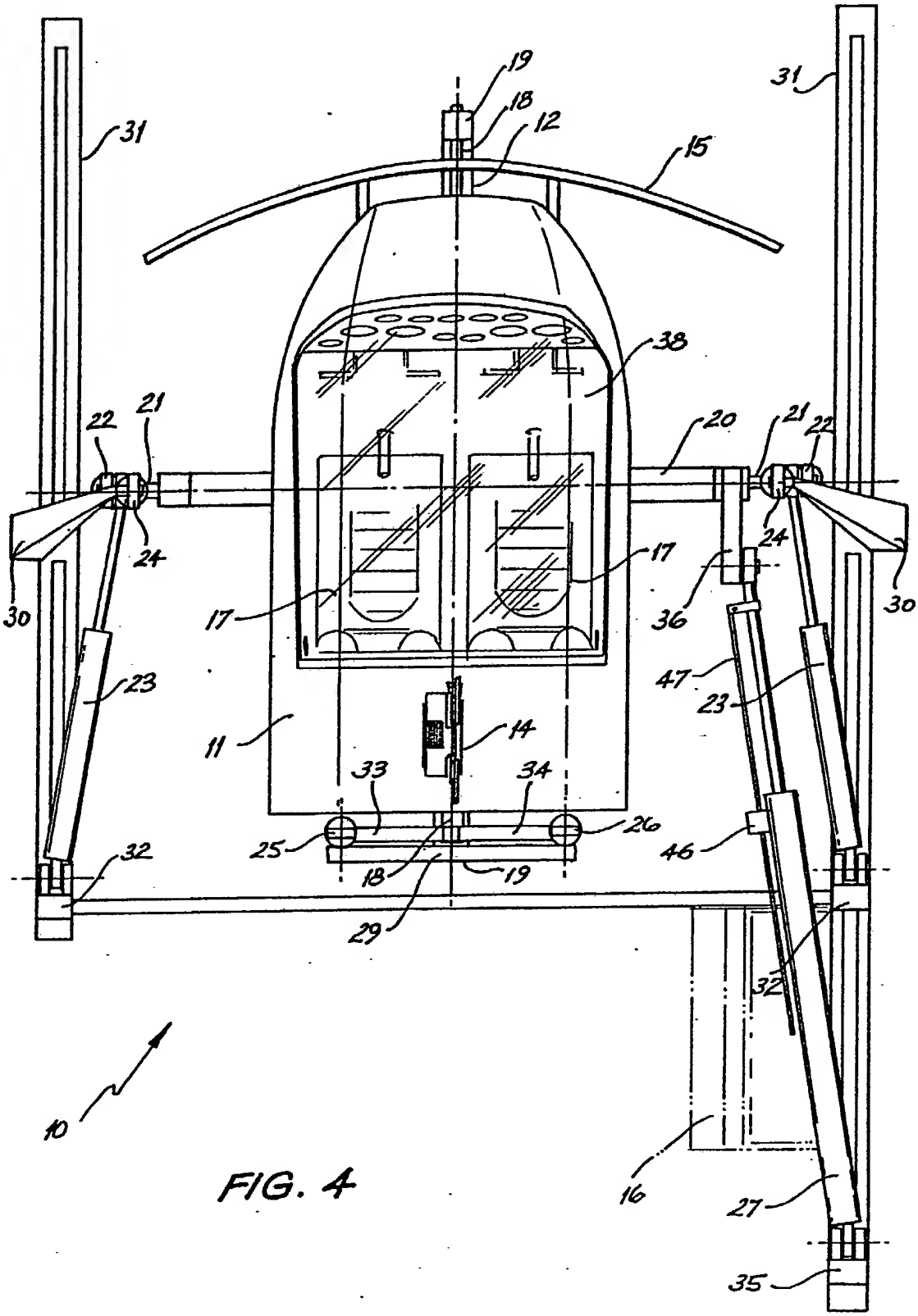


FIG. 4

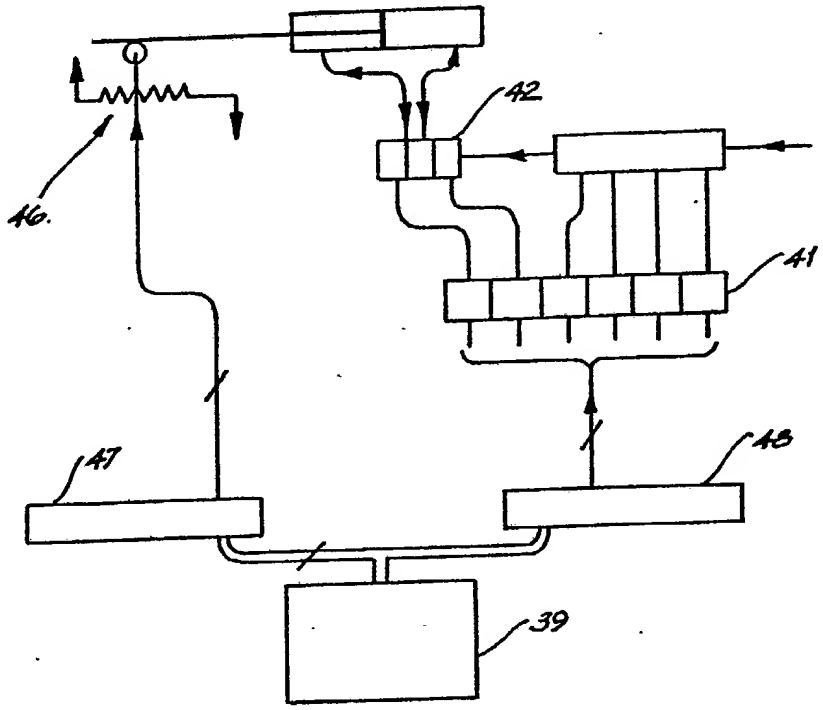


FIG. 5

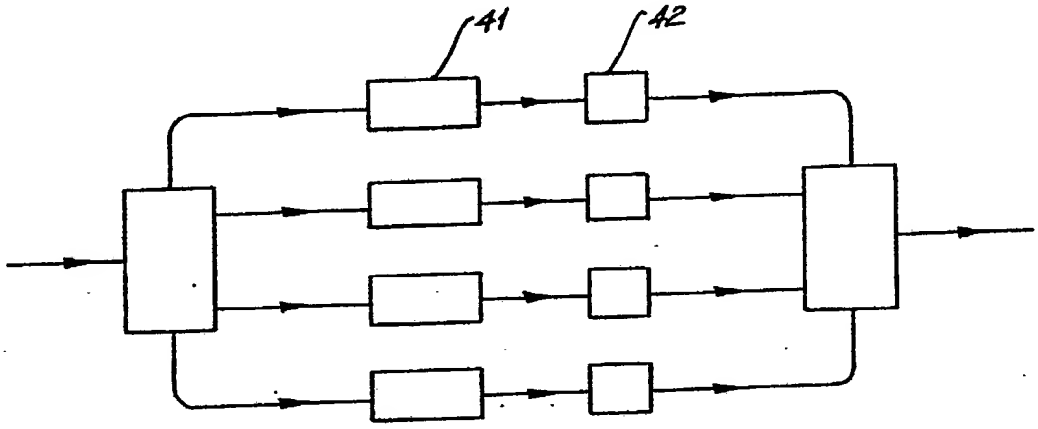


FIG. 6

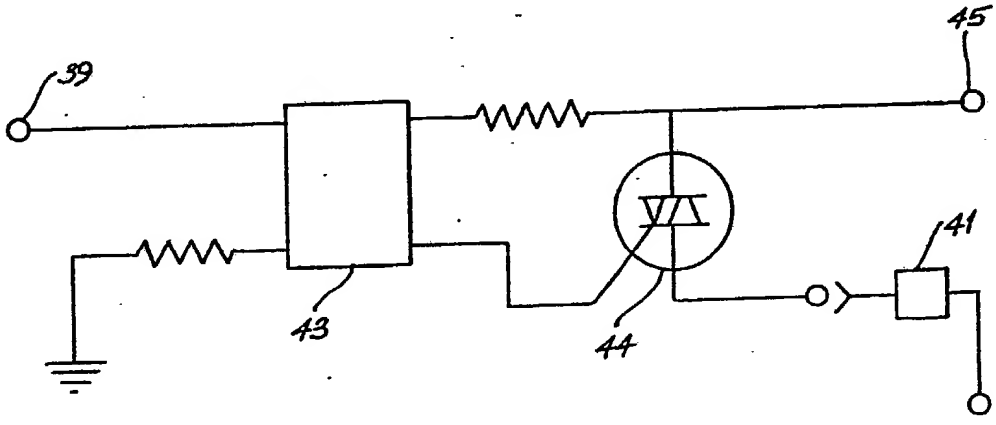


FIG. 7

# INTERNATIONAL SEARCH REPORT

International Application No PCT/AU82/00201

## I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl[3] G09B 9/08 A63G 31/16

## II. FIELDS SEARCHED

Minimum Documentation Searched [4]

| Classification System | Classification Symbols |
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| IPC | G09B 9/08 , A63G 31/16 |

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [5]

AU : IPC as above; Australian classification 90.3; 90.5.

## III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

| Category * | Citation of Document, [16] with indication, where appropriate, of the relevant passages [17] | Relevant to Claim No. [18] |
|---|---|---|
| X | US,A, 3261912 (HEMSTREET) 19 July 1966 (19.07.66) | (1-10) |
| X | US,A, 3233508 (HEMSTREET) 8 February 1966 (08.02.66) | (1-10) |
| X | US,A, 3650045 (WOOD, et al) 21 March 1972 (21.03.72) | (1-10) |
| X | GB,A, 1385186 (REDIFON LIMITED)26 February 1975 (26.02.75 | (1-10) |
| X | US,A, 3718989 (MCKNIGHT) 6 March 1973 (06.03.73) | (1-10) |
| Y | US,A, 2999322 (HEMSTREET)12 September 1961 (12.09.61) | (1,5) |
| Y | GB,A, 1385908 (REDIFON LIMITED) 5 March 1975 (05.03.75) | (1 ) |
| Y | US,A, 3529354 (ROBERTS, et al) 22 September 1970 (22.09.70) | (1-4) |
| Y | US,A, 3597857 (AKISTER) 10 August 1971 (10.08,71) | (1-4) |

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## IV. CERTIFICATION

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|---|---|
| 18 February, 1983 (18.02.83) | 22 February 1983 (22.02.83) |
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